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Theoria cum praxi: Leibniz's Legacy into the Future

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Theoria cum praxi [theory together with practice], the motto Leibniz placed at the beginning of some of his writings (Vermeulen 2015, 41), encapsulates the principle that motivated and guided Leibniz throughout his life. Leibniz conceived the true value of theoretical inquiry to lie in its capacity to enhance the common good. His inquiries were never conducted purely for knowledge's own sake. Rather, he considered every area of study to have some practical value:

[i]f we regard the disciplines in themselves, they are all *theoretical*; if their application, they are all *practical*. (*Dissertatio de Arte Combinatoria* [Dissertation on the Art of Combinations], 1666. A VI 1, 229; L 74)

In Leibniz's age, the improvement of health, living and working conditions and the securing long-term peace among the peoples of a war-torn Europe were key areas where the application of theory to practice could produce the greatest beneficial outcomes. Poverty, ill-health and war remain major concerns, but the most pressing issues of our own age coalesce around the destruction of the natural environment due to exploitative and disrespectful human action, manifesting today in anthropogenic global climate change. It is the contention of this paper that various of Leibniz's strategies in relation to *theoria cum praxi* might usefully be invoked to help heal the fractured, dysfunctional relationship between humans and the rest of the natural world.¹

Following some introductory remarks on Leibnizian harmony and his proposed strategies for the restoration of harmony through the resolution of conflicts, sections I and II consider Leibniz's theoretical studies on language and conceptual analysis and their role within Leibniz's efforts to foster European-Chinese cultural exchange. Leibniz was convinced that

¹ The full potential of Leibniz's philosophy for environmental thought and policy has yet to be fully explored, but see Merchant (1980, 279-83); O'Briant (1980), Shirkova-Tuiat (1998), Phemister (2001, 2003, and 2016).

the advancement of peace and harmony among humans was most effectively secured through encouraging mutual understanding and collaborative enquiry. Cultural exchange has a part to play, but so too do the research investigations and practical projects tasked to the scientific academies envisaged by Leibniz, to which we turn in section III. Finally, in section IV, we discover how today Leibniz's approach and vision resonates, albeit implicitly, in the methods and aspirations of Denise Herzing's fascinating Wild Dolphin Project. In this, we find the Leibnizian vision of mutual understanding and respect among humans being extended beyond the human, helping to foster harmonious relationships between humans and other creatures in nature and encouraging the development of sound environmental policies for their protection.

Principles of harmony, unity, variety and order or perfection pervade Leibniz's theoretical philosophy. On his view, the world is a harmonious ordering of perceiving and embodied substances. Each perceives the same world, but does so from its own unique perspective through the prism of its own body located in its particular position in space and time. Each individual's body is in constant flux as it responds and adapts to alterations taking place in the world at large. In parallel, each individual embodied soul or entelechy, as a "living mirror" of the world, is also constantly changing as it reflects or registers changes happening in each and every one of the world's constituent entities. As reflections of this changing whole, each individual's perceptions correspond in content, structure and order to the content, structure and order of the world itself. Individuals' differing perspectival viewpoints mean that not all – and not always the same – parts of this orderly structure are perceived distinctly by each individual: a fish perceives the environment of the ocean relatively distinctly, but perceives the terrestrial environment only obscurely or insensibly, while the opposite is the case for land-bound mammals. Nevertheless, all perceive the same world and in this way, the universe as the aggregate whole comprising these mutually perceiving beings, is itself both varied and ordered and, indeed, perfect. Unfortunately, however, this mutual correspondence of individuals' perceptions is not matched by harmonious social and ethical relations among living beings. Just as in Leibniz's age, war and other types of conflict continue to wreck lives, communities and environments. Humans have not yet found ways to live in peace, either with each other or with their nonhuman fellow creatures.

For the resolution of disputes over religious doctrine, Leibniz advocated three strategies: linguistic clarity, religious toleration, and incremental progress (to Bossuet, undated, before 8

May 1699. FC II 264-5; Riley 189-90).² These strategies are easily adapted to other forms of conflict. The injunction to proceed incrementally recognized that the less serious doctrinal differences could be resolved without great difficulty and should be dealt with first, before moving on to tackle more intractable points of disagreement. In advocating toleration, Leibniz was drawing attention to the fact that some differences of opinion really “made no difference” and could easily be “tolerated” by both parties to the dispute without harm being done to the core beliefs that each shared. The first strategy, clarification of linguistic terminology, is the most significant for the purposes of this paper. Here, Leibniz points out that some disagreements are purely verbal, arising simply from semantic misunderstanding (to Bossuet, no date, post 8 May 1699. FC II 264; Riley 189). When the meanings of the terms used on either side are clarified, understanding is restored and disagreement dissolved. Terminological clarity, in turn, is sought through analysis of the concepts signified by the terms employed on both sides. Conceptual analysis exposes those points where the disputants, using different terminology, appear to disagree, but are fundamentally in agreement because their respective terms actually refer to the same concept. In the following section, we outline Leibniz’s views on the analysis of concepts and terms and his vision of a universal language. In the subsequent section, we will see how Leibniz used concept analysis to help resolve the question whether the Chinese had a concept akin to that of the Western concept of the Christian God.

I. Languages, the language of thought and the *ars characteristica*

Leibniz’s early steps towards the development of a universal language are found in his *Dissertation on the art of combinations*, published in 1666.³ The first task is to identify the simple concepts or terms⁴ that provide the building blocks from which more complex concepts are formed. Complex concepts are to be analyzed into their simpler and ultimately into their simplest, not further analysable, components. So, for instance, concept *x* might be

² Roinila summarizes Leibniz’s three strategies as follows: “The first one was the exactness of language (all the participants understand all the concepts the same way – one reason more to develop the *characteristica universalis*!), the second was the religious tolerance and the third one was progress in little steps (one should leave the most difficult issue to be solved last)” (Roinila 1997, 112).

³ Leroy Loemker describes the *Dissertation* as containing “the germ” of Leibniz’s plan to establish “a universal characteristic and logical calculus” (L 73).

⁴ Massimo Mugnai explains that Leibniz is known to have used “the Latin expression corresponding to the English word ‘term’ in a quite loose way, sometimes referring to the concept associated with a given word, sometimes referring to the linguistic term itself, and sometimes, finally, meaning the complex made of a word *and* a concept” (Mugnai 2018, 188).

found to include simpler concepts AB and CD and these in turn are analyzable into the simple parts, A, B, C, and D. The next task is to devise a reliable truth-checking and truth-producing mechanism – effectively a universal grammar – for recombining or synthesizing the simple concepts into complex ones. Recombination can be used to confirm previously analyzed concepts and may, in some cases, lead to the discovery of new concepts, as, for instance, to the complex ABCD, previously analyzed into sub-complexes AB and CD, there might be added AC and BD provided the combinatory mechanism or syntax of the language permits.⁵

In the years following the publication of the *Dissertation* and through the Paris years of 1672-1676, Leibniz set his mind to devising a *characteristica universalis* [universal characteristic] or alphabet of thought. The idea was to assign a non-semantic sign or symbol to each simple concept. These signs would be such that they incorporated the basics of a universal grammar or set of rules for their combination into complex terms and propositions. Again, the procedure would serve both as a method for demonstrating known truths and as a tool for the discovery of new truths:

one can devise a certain alphabet of human thoughts and [that], through the combination of the letters of this alphabet and through the analysis of words produced from them, all things can both be discovered and judged. (*Preface to a Universal Characteristic*, 1678-79. A VI 4, 265; AG 6-7)

For Leibniz, it was important that the signs or symbols were not words taken from any actual spoken language and should be such that they are accessible to all peoples irrespective of their own natural language (Perkins 2004, 142). “Ordinary languages,” writes Leibniz, “are guilty of countless equivocations and cannot be used to perform the task of a calculus” (A VI 4, 919; Dascal 1987, 182). No two people understand the same word or sound in exactly the same way. What is needed for the *characteristica universalis* are ideographic characters that directly represent their ideas or concepts, without the intervention of sounds are interpretable in diverse ways by different people (Perkins 2004, 142). In short, as Marcelo Dascal explains, the kind of algebraic reasoning envisaged by Leibniz’s universal characteristic requires that “our thought be ‘blind’, i.e. that the mind concentrate exclusively on the signs themselves and

⁵ *Dissertatio de Arte Combinatoria* (A VI 1, 165-230; part of which is in L 76-80).

on the operations performed upon them, without caring to ‘interpret’ these signs as it proceeds” (Dascal 1987, 43).

Nevertheless, the connection between the symbol and the concept is not an arbitrary association. Rather the sign or symbol attached to a simple concept should be such that it contains some indication of the relations the concept has to other concepts with which it might be combined (Perkins 2004, 142).⁶ Among possible candidates, we know that Leibniz considered seriously the ideographic characters of the Chinese.⁷ However, in the *Dissertation*, he proposed using a numerical symbolism (A VI 1, 195). Leibniz’s *Elementa Calculi* [Elements of a Calculus] (April 1679) contains a helpful illustration of how this might work. Analyzing the complex concept “man” into the component concepts “animal” and “rational”, and assigning the number “2” to “animal” and “3” to “rational”, Leibniz proposes that the number to be assigned to “man” be calculated simply by multiplying “2” by “3”, giving “6” as the number for “man”.⁸ The factors of the number assigned to any given concept indicate simpler concepts contained therein. Since “6”, the number for “man”, has factors “2” (signifying “animal”) and “3” (signifying “rational”), we can conclude (if we did not already know) that anything that is a man is also an animal and is rational. In general, the characteristic numbers assigned to particular species of animals will be divisible by 2, but the characteristic numbers assigned to non-rational animals, although divisible by 2, will not be divisible by 3. So, *if* horses are non-rational animals, the term “horse” might be assigned the even number “10”, but could not be given the number “12”, since 12 is divisible by 3.⁹

Once the simple concepts have been identified through analysis, their characters assigned, and the syntactical rules for their synthesis or combination determined, we would have at our disposal a properly universal language,¹⁰ useful both for the verification and for the discovery

⁶ See also *Preface to a Universal Characteristic* (A VI 4, 269-70; AG 10).

⁷ Perkins (2004, 141-6) details Leibniz’s deliberations on Chinese ideographic characters and his hopes that they might be adapted in ways that would allow them to serve as characters in his own universal characteristic.

⁸ “The one rule for discovering suitable symbolic numbers is this: that when the concept of a given term is composed directly of the concepts of two or more other terms, then the symbolic number of the given term should be produced by multiplying together the symbolic numbers of the terms which compose the concept of the given term” (*Elements of a Calculus*, LLP 17; C 49).

⁹ Conversely, if the number for “horse” were 12 and hence divisible by 2 and by 3, this would indicate that horses were indeed rational animals.

¹⁰ The development of a universal language has been described by Mugnai as “the most precocious and the most persistent” of Leibniz’s philosophical projects (Mugnai 2018, 177).

of previously unknown truths.¹¹ The universal language would facilitate communication and foster mutual understanding. Assuming with Spinoza and Hume that we find it easier to love those with whom we feel the greatest affinity, the use of a common language can be expected to promote loving, peaceful relations between people. An example of Leibniz making use of linguistic analysis to help establish peaceful relations among peoples can be seen in his efforts to promote cultural engagement between Europe and China, to which we now turn.

II. China: language, religion and cultural exchange

From his youth to the end of his life, Leibniz's fascination with China and its culture remained unabated. Franklin Perkins reminds us that Leibniz refers to the pictographic rather than phonetic nature of the Chinese language in his 1666 *Dissertation on the art of combinations* and that one of only a handful of books Leibniz published in his lifetime was an edited collection of writings on China, the 1697 *Novissima Sinica* [*News from China*]. Even at the very end of his life, Leibniz was working on his longest and most detailed essay on Chinese philosophy – his unfinished 1716 *Discourse on the Natural Theology of the Chinese* (Perkins 2004, 42-3). Here, we focus on this unfinished work and in particular on an argument there that will lead us back to the early programme of the *art of combinations*.

Perkins conceives Leibniz's central motivation in respect of China as his “desire to increase the exchange of knowledge between China and Europe” (Perkins 2004, 118).¹² Undoubtedly, East and West had much to learn from each other. However, an even more fundamental goal underpins this epistemological advancement: the promotion of peace between nations. Knowledge of the other's culture and values, history and traditions, science and technology engenders the mutual understanding, trust and respect upon which peaceful and harmonious relationships among people are built.

As was noted earlier, Leibnizian individuals are “living mirrors” that express the world from their own unique perspectives, each perceiving the world through their bodies that locate

¹¹ Relatedly, Leibniz also envisaged the compilation of an encyclopaedia of human knowledge that would draw together into one repository all that was currently known in each area of enquiry and be, essentially, a record of the current state of play and the starting point upon which to build and expand. The academies (see section III below) were conceived as essential for the implementation of this vision.

¹² This desire is second only to the primary ambition to achieve conversion of the Chinese to the Christian faith (Perkins 2004, 122).

them in a particular time and place.¹³ From these perspectives, no finite being expresses the whole with absolute distinctness. What one expresses only confusedly, another may express distinctly. What is known or understood distinctly within one culture may be only dimly perceived within another. Contact with another culture, however, can bring to the surface ideas and ways of thinking that would otherwise have remained hidden from within one's own culture. Sometimes, ideas may be distinctly perceived on both sides of the exchange, yet their agreement is not recognized because each, speaking in their own natural tongue, fails to appreciate the linguistic references of the other. From this can arise needless confusion, misunderstanding, disagreement and dispute. Close analysis of the terms used on either side can help to determine whether there really is disagreement or whether differences in the languages has merely obscured an underlying basic agreement.

In regard to European relations with China, the possibility of Chinese conversion to Christianity was high on the agenda, together with the related question whether the Chinese had any concept resembling the idea of a Christian God.¹⁴ It is to this related question that Leibniz applies the analysis of concepts or terms into their simpler parts that he had proposed in his youthful *Dissertation on the Art of Combinations*.

The Christian God is conceived as omnipotent, omniscient, omnibenevolent, but also as the self-caused, absolute, eternal, infinite, unique, immaterial, indivisible, incorruptible, unchanging, all-perfect substance or unity, the Sovereign Reason, intelligence and pure activity that is Creator and Lord of Heaven and Earth. Furthermore, the Christian God is understood to be the supreme law-maker and law-keeper who ensures, as Leibniz states in §15 of the *Principles of Nature and Grace*, that “there is no crime without punishment, no good action without a proportionate reward” (G VI 605; L 640). In the *Discourse on the Natural Theology of the Chinese*, Leibniz examines the Chinese terms “Li”, “Xangti” and, to lesser extent, “Tien-Chu” in order to assess whether they might be regarded as equivalent to the Western term for “God”. Leibniz's methodical analysis of the term ‘Li’ is a particularly

¹³ See Perkins (2004, 63-5, 81-2).

¹⁴ This was bound up with the so-called “Rites Controversy”. If the Chinese were essentially atheists, then their seemingly religious rituals and traditions might remain in place even after their conversion to Christianity. However, if the Chinese believed in the existence of a non-Christian god, then their rituals and traditions would effectively be religious in nature and would need to be abandoned were they to convert to Christianity. Clearly, this dilemma might be resolved if, as Leibniz argued, the god of the Chinese was in fact identical with the God of the Christians. For discussion of Leibniz and the Rites Controversy, see Perkins (2004, 26-32, 190-4).

thorough investigation in which he attempts to demonstrate that all the features of the Christian God listed above are also present in the Chinese concept of the Li.¹⁵ Believing he

¹⁵ *Discourse on the Natural Theology of the Chinese*, §§4-9. Dutens IV 172-4; CR 79-83). Li is “the foundation of all nature”, “the most universal reason and substance”, of which “there is nothing greater nor better.” Li is the “great and universal cause.” Li is “pure, motionless, rarefied, without body or shape, and can be comprehended only through the understanding” (*Discourse* §4. Dutens IV 172; CR 79). Li is also “the law which directs all things and is the intelligence which guides them ... It is the Law and universal Order, according to which Heaven and Earth have been formed ... the origin, source and principle of all which has been produced” (*Discourse* §4a. Dutens IV 172; CR 79).

The Li is also unique and self-caused. It has no need to rely on the action of any other deity, but is “sufficient unto itself.” It is the eternal “cause” that moves “Heaven, throughout the centuries, in a uniform motion.” Li has “dominion over all; it is present in all things, governing and producing all as absolute master of Heaven and Earth” (*Discourse* §4a. Dutens IV 172; CR 79-80). Leibniz points out that according to Father Longobardi, the Chinese regard the Li as “(par excellence) the Being, the Substance, the Entity,” the “infinite, eternal uncreated, incorruptible” substance that has no beginning and no end. As the source of everything, it is “not only the principle of the physical basis of Heaven and Earth and other material things, but also the principle of the moral basis of virtues, customs, and other spiritual things.” Without body, it is invisible. More than this, this substance Li is “perfect in its being to the highest degree, and it is itself all perfections” (*Discourse* §5. Dutens IV 172-3; CR 80). Li is called “the Supreme” or the “Summary Unity”. This unity is the only unity that is “absolutely unitary” and “not at all capable of divisibility as regards its being.” At the same time, however, Li is the “principal basis of all the essences which are and which can exist in the world.” Li is also, however, “the Aggregate or the most perfect multiplicity” for it “contains the essences of things as they are in their germinal state.” Leibniz goes on to suggest that this be understood in keeping with Christian doctrine that holds that “the ideas, the primitive grounds, the prototypes of all essences, are all in God” (*Discourse* §6. Dutens IV 173; CR 80). Later in the *Discourse*, Leibniz even goes so far as to claim that the Li contains possible essences from which it then chooses to create those that are “the most appropriate” and that the Chinese had in effect formed the “idea of things being created by their natural propensity and by a pre-established harmony” (*Discourse* §18. Dutens IV 179; CR 93).

A further feature of the Li requires a creative interpretation if it is to be brought into line with Christian thought. Longobardi had favored a materialist reading of the Li, grounded in his understanding of the Li as the “Grand Void, the immense capacity (or Space)” that “contains all particular essences.” To Longobardi’s absolutist reading of the spatial void, Leibniz counters his own relational understanding of space. Under this light, the spatiality of the Li can be understood in the Leibnizian sense “not as a substance which possesses parts upon parts, but as the order of things insofar as they are considered existing together, proceeding from the immensity of God inasmuch as all things depend upon him at every moment.” In this sense, Li refers to the ordering of things that “arises from their relationship to a common principle” (*Discourse* §7. Dutens IV 173; CR 80-1). (See also Leibniz’s rejoinder to Longobardi’s materialist understanding of the Chinese axiom that “all things are one.” Leibniz proposes to understand the axiom that “all things are one” in a rational, less literal fashion: all things are one in the sense that they are “all composed of the same prime matter, which differs only by the forms which motion gives it” (*Discourse* §§21. Dutens IV 180; CR 94-5). God is not “the mass of all things”, but rather the cause from which all things derive: “all things are one by emanation (emanenter), because they are the immediate effects of Him” (*Discourse* §22. Dutens IV 181; CR 95)).

Leibniz also attributes a non-literal meaning to Chinese references to the Li as a globe or a circle. This, he claims, is not unlike Western references to “God as being a sphere of a circle whose center is everywhere and whose circumference is nowhere.” Leibniz advises too that Chinese references to the Li as “the Nature of things” that “possesses Truth and Goodness par excellence” are to be read as akin to Western claims that “God is the Natura Naturante” and that this “Nature is wise” and “that she does all for an end and nothing in vain” (*Discourse* §8. Dutens IV 173; CR 82-3).

has shown that the concept of the Li is effectively the same as the Christian concept of God, Leibniz ends his analysis by posing the rhetorical question: “can we not say that the Li of the Chinese is the sovereign substance which we revere under the name of God?” (*Discourse* §9. Dutens IV, 174; CR 83).

Leibniz conducts similar analyses of the terms “Xangti” (translated as King-on-High, Lord of Heaven) and “Tien-chu”, concluding that they are in essence synonymous both with each other and with “Li” (*Discourse* §28. Dutens IV 186; CR 101-2). Each refers to an eternal being “endowed with all possible perfections,” residing in Heaven and governing the world through the distribution of rewards and punishment where they are due (*Discourse* §28. Dutens IV 186; CR 102).

The identification of Xangti and Li with Reason¹⁶ convinces Leibniz that Chinese theology, like that of Christianity, is a natural theology. He writes:

What we call the light of reason in man, they call commandment and law of Heaven. What we call the inner satisfaction of obeying justice and our fear of acting contrary to it, all this is called by the Chinese (and by us as well) inspirations sent by the Xangti (that is, by the true God). To offend Heaven is to act against reason, to ask pardon of Heaven is to reform oneself and to make a sincere return in word and deed in the submission one owes to this very law of reason. For me I find all this quite excellent and quite in accord with natural theology. Far from finding any distorted understanding here, I believe that it is only by strained interpretations and by interpolations that one could find anything to criticize on this point. It is pure Christianity, insofar as it renews the natural law inscribed in our hearts – except for what revelation and grace add to it to improve our nature. (*Discourse* §31. Dutens IV 188; CR 105).

Finally, Leibniz notes, as Longobardi had also observed, that the “Chinese also attribute to the Li all manner of perfections, so that there can be nothing more perfect. It is the supreme power, the supreme good, the supreme purity. It is supremely spiritual and supremely invisible; in short, so perfect that there is nothing to add” (*Discourse* §8a. Dutens IV 174; CR 83).

¹⁶ “[The scholar Ching-Lu] suggests that reverence should be grounded on reason, by observing the relations and proportions between things; only then is it acceptable to the spirits, or rather to the Xangti, to the Universal Spirit, or if you wish, to the Li, to the supreme reason which governs all” (*Discourse* §54a. Dutens IV 199; CR 121).

On Leibniz's reading, the Chinese concept of God is the same as ours, except for the latter's inclusion of the notions of revelation and of grace. Consequently, had Leibniz fixed upon an appropriate characteristic for his universal language, he would no doubt have assigned the same characteristic number or symbol to the terms for Xangti, Li, Tien-chu and for the Christian God. The universal grammar embedded in the syntax of this characteristic number or symbol would then have revealed the logical, rational connections between all the component parts of these synonymous concepts.¹⁷ Were it realisable, Leibniz's universal language, based on his art of combinations and universal characteristic, would be ideally placed to bring to light the rational order, both physical and moral, of God's creation, and bring to light the notions of revelation and grace, already evident to the Christians, but not yet evident to the Chinese.

Leibniz considered the potential benefits of cultural exchange grounded in his universal characteristic would be advantageous to both parties involved. On their side, the Chinese would discover the logical connection between Xangti and revelation and grace. Through cultural exchange, this gap in the Chinese understanding of the concept of God could be rectified. Conversely, Leibniz's study of Chinese culture convinced him that the Chinese were more advanced in morals than were Europeans.¹⁸ Leibniz believed that the Europeans had lost sight of their natural theology in favor of revealed theology and this had led them to lose sight of the necessary connections between knowledge of God (and His perfections) and the virtuous action that arises naturally from the love of God and the pleasurable perception of harmony and order of that which God has created, which, once perceived, the soul wills to promote and maintain (Perkins 2004, 150).¹⁹ The European focus on revelation rather than reason had obscured the relations between the concepts of God, perfection, pleasure, and

¹⁷ This is because Leibniz's Characteristic is conceived as "a certain writing or language ... which perfectly matches the relations of our thoughts" (Leibniz to Gallois, 19 December 1678. A II 1, 669; quoted and translated in Pelletier 2018, 166). As such it would be capable of demonstrating the agreement of the "relations of our thoughts" to the relations of others' thoughts: for instance, the relations of the thoughts had by the Chinese about Xangti might be shown to agree with the relations of the thoughts had by European Christians concerning God.

¹⁸ Leibniz's assessment of Chinese culture in the *Novissima Sinica* is summed up by Perkins as follows: "Among the Chinese, laws are beautifully directed towards the greatest tranquillity and order. People treat their elders and superiors with such reverence that to speak against one's parents is treated as parricide would be treated in Europe. Between equals, there is remarkable respect and mutual duty. Peasants and servants treat each other so lovingly and respectfully that they go beyond the politest Europeans. The Chinese rarely show any hatred, anger, or excitement" (Perkins 2004, 146).

¹⁹ See also Phemister (2016, 87-9).

virtue, thereby opening the way to non-virtuous action in pursuit of purely personal gain. Through contact with the Chinese, Europeans could regain their traditional natural theological base, which in turn would help revive moral goodness in Europe. Restoration of natural theology would remind European Christians of the divine rational foundation of ethical obligations that direct them towards peace and goodwill and against war. As Leibniz wrote in a letter to the Electress Sophie:

I have said it before, and I say it again: we send missionaries to the Indies to preach the revealed religion. That's all very well. But it seems that we now need the Chinese to send us missionaries in return, in order to teach us the natural religion that we have almost lost. (To Sophie, 10/20 September 1697. A I, 14, 72; LTS 170)²⁰

III. Academies: communication and knowledge expansion

Leibniz's recognition of the potential for mutual benefit in the exchange of ideas and practices between the cultures of Europe and China is a specific example of his more general awareness of the desirability – and indeed the need – for human beings to collaborate with each other in their collective endeavours. He writes in his *Memoir for Enlightened Persons*:

But although individuals of merit and good intention can give us quite fine and quite useful things, it is still true that they could do infinitely better if there were a great deal of understanding and communication between them. For when each person thinks by himself, it happens that different people do the same thing, which is so much time wasted; it happens that those who undertake some project lack knowledge, materials and other aids which able or educated persons could provide for them. And, what is most important, a thousand things can be done by two or three or by several [people] who understand each other, which will never be done, or never be done well, if they work without communicating [...]. (*Memoire pour des Personnes éclairées et de bonne intention* [*Memoir for enlightened Persons of good intention*] §23. A IV 4, 618-9; Riley 109)

²⁰ Cited in support by Perkins (2004, 151).

The scientific societies proliferating across seventeenth century Europe held the key to fostering such collaborative research. Leibniz had first-hand experience of the academic societies of Paris and London. He demonstrated his calculating machine at meetings of both the French Académie Royale des Sciences de Paris and the Royal Society of London and maintained regular correspondence with founding members of both societies, including Christiaan Huygens and Henry Oldenburg, for many years after his departure from Paris in 1676. Back in Hannover, Leibniz set his mind to the establishment of academies in his homeland. Eventually, his efforts bore fruit: on 11 July 1700, Prince-electors Frederick III of Brandenburg founded the Electoral Brandenburg Society of Sciences in Berlin. Leibniz became its first President and promptly established *Theoria cum praxi* as the Society's motto (Arthur 2014, 185). Leibniz tirelessly pursued the founding of academies in Dresden and Vienna, as well as further afield in St Petersburg, but it was not until 1724, eight years after Leibniz's death, that Czar Peter the Great opened the Imperial Academy of Sciences in St Petersburg (Vermeulen 2015, 57).

In keeping with *Theoria cum praxi*, and in sharp contrast to the Academies in London and Paris, Leibniz envisaged his academies as institutions that would not only advance theoretical knowledge, but would also translate these theoretical advances into practical projects that would benefit society at large. To this end, his academies were to include researchers from the pure and applied sciences and from the humanities, as well as professionals, civic administrators and military personnel (Totok 1990, 208), together with practising artisans, technicians and engineers.

Leibniz was keenly aware that the founding of academies relied heavily on political power and will²¹ and similarly alert to the fact that academies require funding to cover researcher and practitioner salaries, building maintenance, equipment expenses, and so forth. Yet, as Leibniz noted in his *Memoir for Enlightened Persons*, except for the Royal Academy of Sciences at Paris, none of the academies “have the means to pay fairly large expenses” (A IV 4, 619; Riley 110). Hence, when Leibniz lobbied the Prince-electors to set up an Academy in Berlin, he took care to include in his proposal a number of self-financing measures, such as

²¹ “[F]rom my youth my final goal has been to act for the glory of God by promoting the sciences, which best mirror the divine power, wisdom and goodness ... I am always prepared to direct my thoughts to this great goal, and I have only been looking for a prince who would share these objectives” (Leibniz to Golovkin, 6 January 1712: FC VII, 502-3; Roinila 1997, 85-6).

granting the Academy monopolies on the sale of schoolbooks and on calendars with pictures of Brandenburg, as well as state funding from income generated by silkworm production (Totok 1990, 208) – eminently practical details that would enable his vision to become a reality.

IV. Ecological lessons

Climate change is arguably the greatest threat to all forms of life in the current age. Increases in extreme weather, food insecurity, disease, poverty, and migration, significant species loss, rising sea levels and local flooding are some of the effects of anthropogenic global warming cited in the 2018 Report of the Intergovernmental Panel on Climate Change (IPCC) that “have already had impacts on organisms and ecosystems, as well as on human systems and well-being” (Hoegh-Guldberg 2018, 177). Urgently, harmony between humans and the rest of nature be restored.

What might we learn from Leibniz as we engage in this task? The immediate response is likely to be ‘nothing’ or at best ‘not very much’. Leibniz’s practical projects aimed at improving life for humans. The wellbeing of other living things in nature was easily overridden in the pursuit of human benefit: for instance, he cared little for the silkworms he thought to exploit to finance the academies. Now, Leibniz’s focus on the human is perfectly understandable. His was an age in which the majority of Europeans endured harsh living conditions, relatively primitive medical care, and survived in the midst of political and theological upheaval. The natural world, in contrast, was fairly stable and predictable. Its wellbeing did not give cause for alarm. That being the case, Leibniz’s general lack of concern for the nonhuman might lead us to infer that his strategies that relate solely to harmony among humans have nothing in them that might provide a route to the building of harmonious and empathic relations with our fellow creatures.

This, however, would be a mistake. For all that Leibniz’s main concern was human wellbeing, his ideas and practices do have wider applicability in helping to restore ecological harmony throughout the natural world. Leibniz’s reminder of the need for collaboration and interdisciplinary research is obviously helpful. So too are his model strategies for engaging those who have the power to effect change but who do not yet possess the sufficient motivation to act. Leibniz’s appeals to powerful rulers focused on finding simple, pragmatic solutions to funding difficulties and emphasizing potential benefits to the rulers’ standing and

esteem. Techniques such as these will prove equally effective in relation to national and international politicians, local councillors, and leaders of small local enterprises or global organizations alike. Local planning officers, for instance, might be persuaded to back ecological house building schemes if they could be convinced of their cost effectiveness and appeal to the voting public. However, the greatest ecological potential may lie in Leibniz's wider vision to advance communication and knowledge through the analysis of language, cultural exchange and collaborations within the academies.

We know that Leibniz intended the Berlin Academy to be far more inclusive than the Academies in Paris and London. Theoreticians from disciplines across both the humanities and the natural sciences were to work alongside practitioners capable of transforming the theoretical results of the former into practical projects to enhance human wellbeing. Even today, however, few research institutes actively encourage interdisciplinary exchanges between scientific and humanities disciplines and fewer still reach out to non-academic practitioners in the wider community, although a trail-blazing few do include poets, playwrights, writers and artists. However, a great many more interdisciplinary research institutes have the capacity, should they choose to exercise it, to open their doors to non-academic town planners, architects, farmers, politicians, local counsellors, military personnel, advertisers, business leaders, and so forth. Widening participation and opening up discussion of environmental issues across society in this way would be a significant step towards developing ideas and projects that promote sustainable living.

An even greater step forward would be the extension of the academies beyond the human to include nonhumans as well as humans. We have seen the potential benefits of engaging in cultural exchanges with people from other nations with different historical backgrounds and social structures. Is there not potential to gain also from similar exchanges with nonhuman beings? And would not the understanding of other creatures that arose from such exchanges encourage and even compel us to consider not just the effects of our behavior on our own environments and the threat it poses for our own continued existence, but also to consider the effects of our actions on the environments nonhumans inhabit and the threat our behavior poses to their continued existence too?

Admittedly, in one sense, nonhumans are already present in many academic research institutes and university laboratories, but only as research objects for observation and

experimentation, not as full co-participants in a mutual exchange of information.

Unquestionably, scientific research that treats nonhuman others as mere objects of research often leads to breakthroughs in the treatment of diseases that are of benefit to the species as a whole. However, treating nonhuman others as mere research objects does nothing to temper our anthropocentric inclinations to value nonhuman beings simply for their utility to humans, as happens, for instance, in the testing of pharmaceuticals and cosmetics on animals prior to their release for use by humans. When researchers are motivated primarily by the perceived or anticipated benefits of the research for human life, there is little incentive – and a deal of disincentive – to enter into empathic - or even sympathetic – relationships with their nonhuman research objects and little associated concern for their wellbeing in and for themselves. More often than not, it is only when harm inflicted on nonhuman species begins to impact badly on human wellbeing that the need to act to protect the nonhuman come into clear focus, as we have seen in the recent upsurge of concern for the decreasing bee population.

Clearly, the inclusion of nonhuman animals in the academies as mere research objects is problematic and hinders our viewing them as ends in themselves with their own needs and desires and their own particular perspectives on the world. To counter this, might nonhuman beings be included in the academies not just as objects of study, but as actual co-participants in collaborative investigations as co-researchers, as it were? Might animals and plants and microorganisms be treated as partners with humans within the academies? Might the academies be extended out into the natural world so that they can engage with us on their own terms beyond the academy walls? Might there be *mutual* exchange of information from human to nonhuman and from nonhuman to human, so that each side might learn from the other? In short, could there be cultural exchange not just between one human culture and another human culture, but also between humans and non-human biological cultures?²²

The proposal to include nonhumans as co-participants in the research investigations of the academies seems preposterous. How could humans collaborate meaningfully with nonhuman beings that don't speak the same language or even have language at all? However, numerous

²² That we use the term “culture” to refer both to human culture and biological or bacterial cultures might give us hope that this question affords an affirmative answer. Interestingly, some biologists are already beginning to consider the possibility that bacteria engage in social behavior (Brown and Johnstone 2001).

studies over the past decade or so have produced widespread evidence of plant, insect and animal communication.²³ Organisms certainly communicate within their own species groups and some are clearly capable of communicating across species boundaries.²⁴ All the same, while studies indicate that members of nonhuman species communicate with members of their own or other species, including humans, they tend not to consider how humans might in turn communicate information to members of nonhuman species. Yet, if nonhumans are to be admitted as partners within the academy and if there is to be genuine *mutual* exchange, the communication has to travel in both directions, from nonhuman to human and from human to nonhuman.

One exceptionally interesting study has come close to establishing two-way communication with another species. For the past thirty years, researchers on the Wild Dolphin Project led by Denise Herzing have been investigating and engaging with Atlantic spotted dolphins in their natural habitat in the Northwest Little Bahama Bank to the north of Grand Bahama Island. Herzing and her research group are building on now well-established research findings that dolphins not only have proper names – signature whistles – that they use to greet and call one another, but also communicate by means of a relatively sophisticated language with its own semantics and syntax. As Herzing reports, “[d]olphins understand word order (syntax), word meaning (semantics) abstract thought, and show self-awareness” (Herzing 2010, 1451). The Wild Dolphin Project researchers’ current aim is not just to interpret dolphin language, i.e. to discern the meanings of the whistles that dolphins use to communicate with other dolphins, but also to open up two-way channels of communication so that information flows not just from dolphins to humans, but also from humans to dolphins.

Observing the dolphins playing a game of “go fetch” with their young, teasing them with a piece of sargassum before dropping it for the young to recover, the Wild Dolphin Project researchers realised that if they could discover the “word” – the dolphin whistle – that the dolphins were using as the sign for the sargassum, differentiate it from signs for other items used in the game and replicate the whistles that the dolphins used, they would have the beginning of a shared language between themselves and the dolphins. To assist them in these endeavors, the researchers use a specially designed underwater computer system, CHAT

²³ On communication among plants, for instance, see Gagliano et al (2017).

²⁴ One might instance here the communication between humans and their companion animals.

(Cetacean Hearing And Telemetry).²⁵ This real-time system translates dolphin whistles first into computer code and then into the sound of the corresponding human word. Conversely, the human terms can be re-translated back into code and then emitted as the appropriate dolphin whistle, thereby opening up a channel for interactive two-way communication between dolphins and humans. Using CHAT, researchers will, it is hoped, be able to call out to particular dolphins using their own signature whistles and also to request them to fetch particular items, as for instance, a piece of sargassum.

CHAT also has the potential to allow for the addition of new “words” into dolphin vocabulary by translating human words into “new” dolphin whistles. This opens up the possibility of introducing dolphin whistles to refer to the scarves and ropes that the researchers have added to the “go-fetch” sargassum game. Wild Dolphin Team members have also have also given themselves their own distinctive signature whistles or “dolphin names”. The hope is that in time CHAT will enable the dolphins themselves to request specific items from humans, and even to request items from a particular human researcher (Herzing 2013).

As with all computer programming, the development of CHAT was made possible only through the discovery of binary arithmetic, a discovery for which Leibniz himself claimed credit. More accurately, Leibniz claimed to have *re-discovered* binary arithmetic, attributing its earlier discovery centuries earlier to the Chinese. The final, though incomplete, part of Leibniz’s *Discourse on the Natural Theology of the Chinese* discusses “the Characters which Fohi, Founder of the Chinese Empire, Used in His Writings,” in which Characters, Leibniz discerns the fundamental units of binary arithmetic:

In Binary Arithmetic, there are only two signs, 0 and 1, with which one can write all numbers. When I communicated this system to the Reverend Father Bouvet, he recognized in it the characters of Fohi, for the numbers 0 and 1 correspond to them exactly if we put a broken line for 0 and unbroken line for the unity, 1. This Arithmetic furnishes the simplest way of making changes, since there are only two components, concerning which I wrote a small essay in my early youth [his *Dissertation on the art of combinations*], which was reprinted a long time afterwards

²⁵ Herzing (2014a).

against my will. So it seems that Fohi had insight into the science of combinations.
(*Discourse* §68a. Dutens IV, 208; CR 133)

Logically combined into all possible groupings of six characters, Fohi's broken and unbroken lines formed the hexagrams of the Yi Kim or Book of Changes.²⁶ Leibniz recognized in this a certain affinity to his own attempts to analyze concepts into their simplest indivisible parts, which parts, having been assigned numerical characters, could then be combined using the syntactical rules of arithmetical multiplication. By this means, every concept might in theory be symbolized numerically, for, as Leibniz notes, all numbers are representable in binary arithmetic as combinations of 0 and 1, or alternatively, by the corresponding Fohi characters, the broken and unbroken lines.²⁷ By the latter part of the twentieth century, the use of "1" to represent "on" and "0" to indicate "off"²⁸ had enabled Leibniz's re-discovery of binary arithmetic to bear fruit through its role in the formation of the modern day computer.²⁹ Today, the development of computer-assisted speech recognition techniques is helping to realize Leibniz's dream of representing words and concepts by numerical characters. Using such techniques to aid communication brings one step closer Leibniz's vision of a universal language. Their use in the Wild Dolphin Project, as we shall discover, has the potential to extend the universality of this language even beyond the human.

Together with computer scientist Thad Starner of Georgia Institute of Technology, Denise Herzing is analyzing the wealth of dolphin vocalization data sets she has amassed over her thirty years of studies on dolphins in the Bahamas. Just as Leibniz had sought to analyze concepts into their simple, unanalyzable component parts and then to determine the rules for their recombination, so too Herzing and Starner have been looking to identify the most fundamental units – akin to individual words – in dolphin vocalizations and seeking patterns in the way these units are combined. To date, they have isolated 12 fundamental units, naming these with the letters A through to L, and have discovered certain rules that appear to govern how these fundamental units are combined: for instance, some of these units are

²⁶ Coincidentally, spectrographic depictions of dolphin sounds are visually remarkably similar to I Ching hexagrams.

²⁷ 1 = 1; 10=2; 11=3; 100=4; 101=5; 110=6; 111=7; 1000=8; and so forth. (*Discourse* §71: Dutens IV, 209; CR 136)

²⁸ Or, in Leibnizian terms, "1" can be taken to represent being (unity) or activity and "0" to represent non-being (nothingness) or passivity.

²⁹ Leibniz recognised that delays in finding practical applications of theoretical results are common. See his remarks to Stahl in defence of anatomical studies (Leibniz-Stahl, LSC 36-7).

frequently combined with certain others – as for instance, C often occurs after J – while others appear never to be found together (Herzing and Starner 2015).

Herzing and Starner have also been looking to link the dolphin vocalizations to dolphins' behavioral patterns and have discovered that the combinatory rules are highly predictive of dolphin behavior.³⁰ So, for instance, certain combinatory rules and patterns occur during foraging, but not during reunion or play, and vice versa. Indeed, with her detailed knowledge of dolphin social interactions, Herzing found that she could predict with a high degree of accuracy what the dolphins were doing simply by listening to the sounds that they were making (Herzing and Starner 2015).

The discovery of rule-governed dolphin language is intriguing and potentially very exciting for it raises the possibility that there might be a universal language that goes beyond even what Leibniz envisaged by extending out to embrace not just humans but language users of all species. Herzing herself raises the question whether there might at least be some “universal features of communication across all species,” but notes also that there has been little research into the issue (Herzing 2014b, 535). However, if communicative sounds made by other species can be analyzed in the same way as have been those of the Atlantic spotted dolphins, comparison of the results across species might lead eventually to the development of a (computer-aided) universal language that would enable all living beings to communicate with each other.

Leibniz's claim that all living beings mirror the order and perfection of the world from their own perspectives provides a metaphysical framework that supports the probability of a syntactical structure common to all the communication systems employed by the various types of living beings. Leibniz insisted that all beings perceive or express the same spatial and temporal ordering of events. All do so through their perceptions of their own bodies, their perceptions reflecting the changes imposed on their own bodies as they are affected by

³⁰ Starner describes the results thus: “we started finding rules. There seems to be a structure in this dataset. There seems to be rules about what can be uttered when, which pattern can be used when in this dataset. And so we can see that some things can be put here and other things can't. That's really exciting. Matter of fact as we went forward we discovered that the rules were better predictive of the visual behavior that we see from the dolphins than anything else. Not just the percentage of the patterns, not what we call normal grammars, but the rules. In other words much more structure than we first thought” (Herzing and Starner 2015).

bodies in the wider, external world : “the soul expresses the state of the universe in some way and for some time, according to the relation other bodies have to its own body” (*Discourse on Metaphysics*, §33. A VI 4, 1582; AG 64-5). Some living beings also use their bodies to express aspects of the world through language or some other form of expressive behavior.³¹ As expressions of the same world that is represented in these creatures’ perceptions, it is reasonable to postulate that the basic elements of the expressing language or expressive behavior – and the ordered structural arrangement of these elements – correspond to the elements and structural ordering of sensory perceptions of the world and to the elements and structural ordering of the world itself. Moreover, given that all living beings perceive or mirror the same world, which world they express through their language and behavioral practices, it is also not unreasonable to presuppose a fundamental common semantic and syntactical structure– a universal language – that constitutes the bedrock of all languages and other communication practices, despite their apparent – and ultimately superficial – differences.

In short, Leibniz’s theoretical metaphysics invites us to expect that across different species, the simple units and syntactical rules of combination of their communications are essentially the same. Although different signs or symbols may be used to refer to these units and combinations, in much the same way as Europeans and Chinese used different terms to refer to God, we may discover cross-species correlations of simple elements and structured ordering. With such a common base, each species might in principle be taught to communicate in the language of another species, just as Europeans and Chinese communicate across cultures when they learn each others’ languages. Alternatively, cross-species communication might be facilitated by the development of a universal language available to all species, akin to the universal human language that Leibniz hoped would enhance understanding across human cultures. In practice, however, neither of these methods is feasible as a means of communication across human and nonhuman species or between different nonhuman species: differences in physical make-up of diverse species are simply too great to permit of one single means of vocalization by some or across all species.

³¹ One well-documented example of expressive behavior is the honeybee waggle dance. See for instance Preece and Beekman (2014).

A further possibility, however, is provided by the Wild Dolphin Project's CHAT system. CHAT can be used, not just as a decoder and translation tool, but also as an interface that can to some extent overcome the communication hurdles posed by differences in organisms' vocalization abilities (Herzing 2014a). Such interface technology, suitably adapted to the physical capabilities of particular species, has the potential to turn every language into a universal language.³² The results for human-dolphin two-way communication using CHAT remain limited at this very early stage. However, the potential is promising. Talking about CHAT in October 2015, Herzing commented:

I've been waiting thirty years for this tool. It's a good example of how important interdisciplinary work is. I mean, as biologists, we live in our little biology world and we don't know you have these great tools in computer science sometime. And to also mention that there are many data sets out there – in my own field and in marine ecology and in prairie dog work – that would use this same tool (it doesn't have to be dolphin vocalizations) to mine the data and really start looking at a lot of systems. So, we're excited about applying this to other colleagues as well - and their lovely data sets. (Herzing and Starner 2015)

Future refinement and development of CHAT as a cross-species communication interface may bring the biological sciences close to realizing Leibniz's dream of a truly universal language. Full realization is a long way off, but at least for now, mutual exchange between humans and dolphins, similar to the mutual exchange between the Europeans and the Chinese, is a live possibility.

Concluding remarks

No obvious historical narrative links Leibniz directly to Herzing. Nevertheless Leibniz's thought and vision undoubtedly played a part in shaping the social, cultural and educational environment and aspirations from which the Wild Dolphin Project has arisen. Without Leibniz's re-discovery of binary arithmetic, the computer technology that is driving forward his particular vision of a universal language facilitating cultural exchange would be unavailable. We can draw inspiration from his persistence to establish truly interdisciplinary

³² In this regard, Douglas Adam's science fiction depiction of the Babel fish in the *Hitchhiker's Guide to the Galaxy* may prove prescient (Adams 2009 [1979], 55).

research academies where findings of theoretical research give rise to practical projects directed to the common good. Interdisciplinary research has been key to the ongoing success of the Wild Dolphin Project, but even more significant is the potential of this project to enhance the common good by increasing our understanding of, and two-way communication with, other living beings.

Leibniz's analysis of concepts, their representation by characters, his promotion of Chinese cultural exchange and his efforts to establish interdisciplinary academies were not just an epistemological exercise in the documentation and advancement of human knowledge. Leibniz's overriding primary goal was the advancement of peace and harmony among peoples and cultures through mutual understanding and respect. Might we now also reach out to other species, as Herzing has done with the Atlantic spotted dolphins, engaging with them in cultural exchange? And as we come to understand them and they us, might we also, following Leibniz's lead, hope that mutual understanding and respect will help establish sufficient common ground and shared purpose to underpin a long overdue ecological restoration of harmonious co-existence between humans and nature?

References

Adams, Douglas. 2009 [1979]. *The Hitchhiker's Guide to the Galaxy*. London: Macmillan Children's Books.

Arthur, Richard. 2014. *Leibniz*. Cambridge: Polity Press.

Brown, Sam P. and Rufus A. Johnstone. 2001. "Cooperation in the Dark: Signalling and Collective Action in Quorum-Sensing Bacteria". *Proceedings of the Royal Society Biological Sciences* 268 (1470), 961-65.

Dascal, Marcelo. 1987. *Leibniz: Language, Signs and Thought: A Collection of Essays*. Amsterdam: John Benjamins Publishing Company.

Gagliano, Monica, John C. Ryan, and Patrícia Vieira (eds.). 2017. *The Language of Plants*. Minneapolis: University of Minnesota Press.

Herzing, Denise L. 2010. "SETI meets a social intelligence: Dolphins as a model for real-time interaction and communication with a sentient species". *Acta Astronautica* 67, 1451-4.

Herzing, Denise L. 2013. "Could we speak the language of dolphins?" TED talk, 6 June 2013. <https://www.youtube.com/watch?v=CQ5dRyyHwfM>, visited 14 December 2018.

Herzing, Denise L. 2014a. "CHAT: Is It A Dolphin Translator Or An Interface?". <http://www.wilddolphinproject.org/chat-is-it-a-dolphin-translator-or-an-interface/>, visited on 14 December 2018.

Herzing, Denise L. 2014b. "Clicks, whistles and pulses: Passive and active signal use in dolphin communication". *Acta Astronautica* 105, 534-7.

Herzing, Denise L. and Thad Starner. 2015. "Dolphin Communication: Cracking the Code". IPaT Distinguished Lecture Series, October 20, 2015. <https://www.youtube.com/watch?v=blmTrZMTcUs>, visited on 17 December 2018.

Hoegh-Guldberg, O., et al. 2018. "Impacts of 1.5°C Global Warming on Natural and Human Systems." V. Masson- Delmotte, et al. *Global Warming of 1.5°C. An IPCC Special Report on the Impacts of Global Warming of 1.5°C above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty* (2018). <https://www.ipcc.ch/sr15/>, visited on 28 January 2019.

Merchant, Carolyn. 1980. *The Death of Nature: Women, Ecology and the Scientific Revolution*. New York: Harper and Row.

Mugnai, Massimo. 2018. "Ars Characteristica, Logical Calculus, and Natural Languages". *The Oxford Handbook of Leibniz*. Edited by Maria Rosa Antognazza. Oxford: Oxford University Press, 177-209.

O'Briant, Walter H. 1980. "Leibniz's Contribution to Environmental Philosophy". *Environmental Ethics* 2(3), 215-20.

Pelletier, Arnaud. 2018. "The *Scientia Generalis* and the Encyclopaedia". *The Oxford Handbook of Leibniz*. Edited by Maria Rosa Antognazza. Oxford: Oxford University Press, 162-76.

Perkins, Franklin. 2004. *Leibniz and China: A Commerce of Light*. Cambridge: Cambridge University Press.

Phemister, Pauline. 2001. "Leibniz and Ecology". *History of Philosophy Quarterly* 18(3), 236-58.

Phemister, Pauline. 2003. "Exploring Leibniz's Kingdoms: A Philosophical Analysis of Nature and Grace". *Ecotheology* 7(2), 126-45.

Phemister, Pauline. 2012. "Relational Space and Places of Value". *Transformative Values: Human-Environment Relations in Theory and Practice*. Edited by Emily Brady and Pauline Phemister. Dordrecht: Springer, 17-30.

Phemister, Pauline. 2016. *Leibniz and the Environment*. Abingdon: Routledge.

Preece, Kaitlyn and Madeleine Beekman. 2014. "Honeybee waggle dance error: adaptation or constraint? Unravelling the complex dance language of honeybees". *Animal Behavior* 94, 19-26.

Roinila, Markku. 1997. *G. W. Leibniz's Philosophy and Practical Projects*, Licentiate Thesis 1997. <http://www.helsinki.fi/%7Emroinila/ownstuff.htm>, visited 5 March 2018.

Shirkova-Tuuli, Irina. 1998. "On the Concept of Ecological Optimism". Twentieth World Congress of Philosophy, Boston, Massachusetts, 10-15 August 1998. <https://www.bu.edu/wcp/Papers/Env/EnvShir.htm>, visited on 7 July 2018.

Totok, Wilhelm. 1990. "Leibniz – Founder of Scientific Academies". *International Science Reviews* 15(3), 207-8.

Vermeulen, Han F. 2015. *Before Boas: The Genesis of Ethnography and Ethology in the German Enlightenment*. Lincoln, NE: University of Nebraska Press.